THE OBSERVED CORRELATIONS FOR THE STRANGE MULTIBARYON STATES IN SYSTEMS WITH Λ-HYPERON FROM pA COLLISION AT MOMENTUM OF 10 GeV/c

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The observed well-known resonances Σ^0 $\Sigma^{*+}(1385)$ and $K^{*\pm}(892)$ from PDG are good tests of this method. Exotic strange multibaryon states have been observed in the effective mass spectra of: $\Lambda\pi^{\pm}$,$\Lambda\gamma$, Λp, Λpp subsystems. The mean value of mass for $\Sigma^{*-}(1385)$ resonance is shifted till mass of 1370 MeV/c^2 and width is two times larger than the same value from PDG. Such kind of behavior for width and invariant mass of $\Sigma^{*-}(1385)$ resonance is interpreted as extensive contribution from stopped $\Xi^- \rightarrow \Lambda\pi^-$ and medium effect with invariant mass. The mean value of mass for $\Sigma^{*+}(1385)$ from secondary interactions is also shifted till mass of 1370 MeV/c^2. The width of Σ^0 is ≈ 2 times larger than the experimental error. There are enhancement production for all observed hyperons.

1 Introduction

Observation of strange multi-baryonic clusters is an exiting possibility to explore the properties of cold dense baryonic matter and non-perturbative QCD [1-9].

The experimental data from heavy ion collisions show that the K^+/π^+ ratio ([8]) is larger at BNL$-$AGS energies than at the highest CERN$-$SPS energies and even those at RHIC. The experimental Λ/π^+ ratio in the pC reaction is approximately two times larger than this ratio in pp reactions or in pC reactions within the FRITIOF model at the same energy [21]. However, there are no sufficient experimental data concerning strange hyperon production in hadron$-$nucleus and nucleus-nucleus collisions over the 4$-$50 GeV/c momentum range.

Recently, the existence of discrete nuclear bound states of $\overline{K}^0$p has been predicted within the phenomenological Kaonic Nuclear Cluster (KNC) model based on the experimental information on the $\overline{K}^0$N scattering lengths, kaonic hydrogen atom, and the $\Lambda^*(1405)$ resonance [4], [5].

Although such states were predicted by Wycech[?] some time ago, only recently the availability of experimental facilities (KEK [10],[11], DISTO [16], FOPI [15], DAFNE [14], and OBELIX [17], in particular for studying these kind of exotic nuclei, has delivered first experimental results which triggered a vivid discussion and project of AMADEUS [13].

As was shown [9], the strangeness production in p annihilation on nuclei and on hydrogen are related to the possible quark-gluon plasma formation and to the existence of DBKS in dense hadronic matter.

Following [8], we assume that the above experimental fact is due to the formation of a 'blob' of QGP.

Experimental evidence for exotic dibaryons in the (Λp) system first came from the observa-

tion of S = -1 narrow resonances by the propane bubble chamber method at the beam momenta of 7 GeV/c [18] and 10 GeV/c [19,20,21].

2 (Λ, π^+), (Λ, p) and $\Lambda\gamma$ spectra

2.1 (Λ, π^+)spectra

The $\Lambda\pi^+$ effective mass distribution for all 19534 combinations with a bin size of 17 MeV/c^2 at 10 GeV/c is shown in Fig.1,a [20,?]. The dashed histogram in the figures is the background simulated by the FRITIOF model. The mass resolution is $\Delta M/M = 0.7\%$, the decay width is $\Gamma \approx 45$ MeV/c^2. The cross section of $\Sigma^{*+}(1382)$ production is approximately 1.1 mb (600 events in the peak, 13σ) for the $p + C$ interaction, which is 1.5 times larger than the estimated cross section. This observed resonance $\Sigma^{*+}(1382) \rightarrow \Lambda\pi^+$ was a good test of this method. The $\Lambda\pi^+$ effective mass distribution for total 25199 combinations with a bin size of 12 MeV/c^2 from primary at 10 GeV/c and secondary relativistic protons over the momentum $4 < P_p < 10$ GeV/c is shown in Fig.1,*b*($\approx$780 events in peak). The secondary protons is a positive tracks with momentum $4 < P_p < 10$ GeV/c,which are induced interaction. The total contribution in positive tracks from another K^+,π^+ particles lower than 15 %. The dashed histogram in Fig.1, *b* is the background by the mixing momentum method. The upper dashed curve (Fig. 1,*a* and *b*) is the sum of the background and 1 Breit-Wigner function. The background (lower dashed curve) is the 8th-order polynomial function. The bin size is consistent with the experimental resolution. There are small signals in mass range of 1450(3.5σ and 1750(3.3σ) MeV/c^2. This enhancements can interpreted as reflection from Λ^* resonances. The mean value of mass in Fig.1, *b* is shifted till 1370 MeV/c^2. The same shift have observed for the mean value of $\Lambda\pi^-$ spectrum [20,?]. Such kind of behavior in both case we can interpreted as medium effect in nucleus from lower energy $\pi^\pm$, because a momentum distributions for π^- from the beam protons and for π^+ from secondary protons have similarly behavior.

2.2 (Λ, p) spectra

In the are published reports [19-21] the (Λp) invariant mass with identified protons is given for the momentum range of 0.350$< p_p <$ 0.900 GeV/c. There are significant enhancements in the mass regions of 2100(6.9 σ), 2175(4.9σ), and 2285(3.8σ)MeV/c^2. There are also small peaks at masses of 2225(2.2σ) and 2353(2.9σ) MeV/c^2.

Figure 1, *c* shows the invariant mass for all Λp 21500 combinations with bin size 8 MeV/c^2 from primary beam protons. There is significant signal in region of 2155 MeV/c^2(¿ 6σ).There are small enhancements in mass regions of 2100, 2212 and 2310 MeV/c^2.

Figure 1, *d* shows the invariant mass of 4669(Λp) combinations with a bin size of 14 MeV/c^2 for stopped protons in the momentum range of 0.14$< p_p <$ 0.30 GeV/c. The dashed curve is the sum of the eight-order polynomial and 4 Breit-Wigner curves with $\chi^2 = 30/25$ from fits. There are significant enhancements in the mass regions of 2100(5.7 σ), 2150(5.7σ), 2220(6.1σ), 2310(3.7σ), and 2380(3.5σ)MeV/c^2. The significant peak in the mass range of 2220 MeV/c^2 (6.1 S.D.), B_K 120 MeV is confirmed by the KNC model prediction [4] in the $K^-pp \rightarrow \Lambda p$ channel.

The Λp effective mass distribution for 4523 combinations with relativistic protons over a momentum range of P >1.5 GeV/c is presented in [21], where the events with the undivided (ΛK^0_s) are removed. The solid curve is the 6-order polynomial function (χ^2/n.d.f=271/126). There are significant enhancements in the mass regions of 2150(4.4 S.D.), 2210(3.8 S.D.), 2270(3.4 S.D.), 2670 (3.1 S.D.), and 2900(3.1 S.D.) MeV/c^2. The observed peaks for the combinations with relativistic P >1.5 GeV/c protons agree with spectra from combination with the identified protons and with stopped protons.

2.3 (Λ, γ) spectra

Figure 1, *d* shows the invariant mass for all $\Lambda\gamma$ 2904 combinations with bin size 9 MeV/c^2 from primary beam protons and without total geometrical efficiency from Λ and γ. The dashed curve is the sum of the six-order polynomial and 1 Breit-Wigner functions. The statistical significance for Σ^0 is 12σ(or 220 events in the peak). There are negligible enhancements in mass range of 1320 and 1380 Mev/c^2.

Figure 1, *f* shows the invariant mass for all $\Lambda\gamma$ 2904 combinations with bin size 10 MeV/c^2 from primary beam protons and with total geometrical efficiency from Λ and γ. The cross section of production for Σ^0($\approx$ 1800 events, $< w_\gamma >$=4.1) is equal to σ= 3.3 mb for p+C interaction at 10 GeV/c which is more 2 times larger than simulated cross section by FRITIOF. The observed width of Σ^0 is $\approx$ 2 times larger than value of experimental errors. There are small enhancements in mass ranges of 1320 ,1380, 1420, 1550 and 1630 with bin size 10 MeV/c^2 which are interpreted as reflection from enhancement production well known hyperons.

3 Conclusion

A number of important peculiarities were observed in the effective mass spectrum[19-21]: $(\Lambda, \pi^{\pm})$, (Λ, π^+, π^-), (Λ, p), (Λ, p, p), (Λ, Λ), (Λ, p, π^-), (Λ, K_s^0), $(K_s^0\pi^{\pm})$ and $(K_s^0 p)$. There are enhancement signals from all observed hyperons[21]. The observed width of Σ^0 and Σ^- is $\approx$ 2 times larger than PDG value.

According to A. Gal [7] and R.Jaffe(proc. J-PARC workshop-2005), the issue of strange multibaryon states is yet far from being experimentally resolved and more dedicated, systematic search is necessary. The search for and study of exotic strange multibaryon states with Λ and K_s^0 subsystems at MPD(NICA, JINR), CBM(FAIR, GSI), p07(JPARC, KEK), OBELIX(CERN) and AMADEUS(DAFNE, INFN) can provide information on their nature and properties and will be a test for the observed PBC data. Higher statistics experiments with the mass resolution $\approx$1% are needed.

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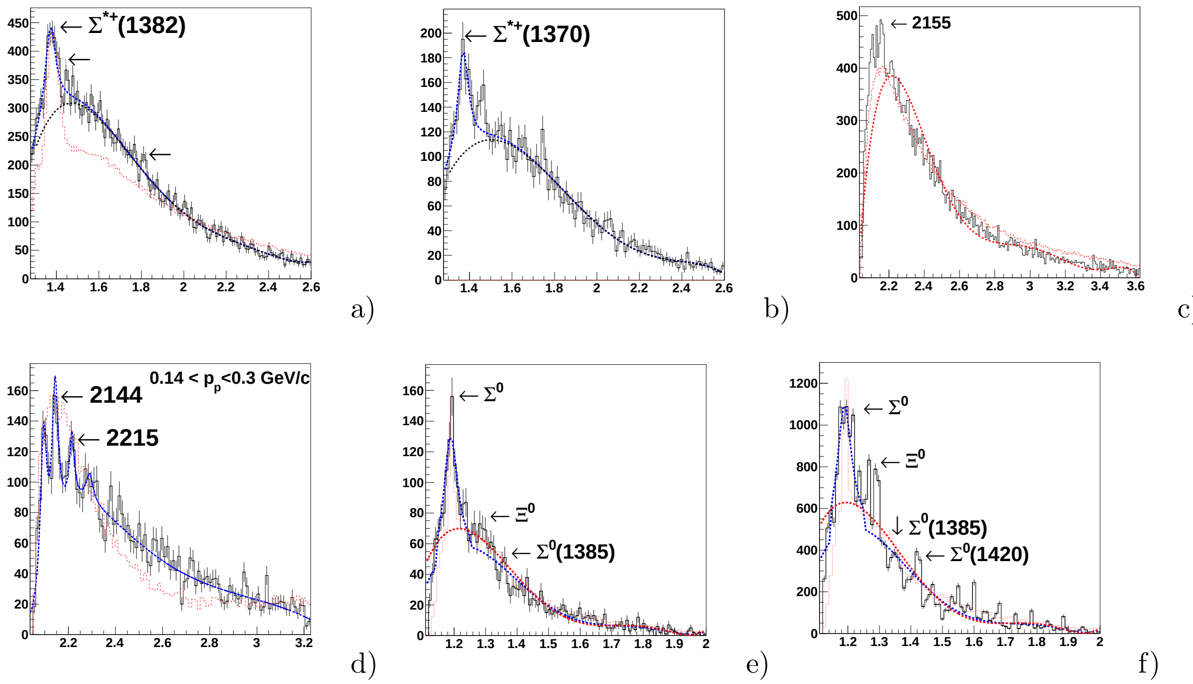

Figure 1: a)The $\Lambda\pi^+$ - spectrum for all combinations with a bin size of 12 MeV/c^2; b) $\Lambda\pi^+$ spectrum from primary and secondary protons; c)the Λp - spectrum for all combinations with a bin size of 8 MeV/c^2 for p+A interactions from primary protons; d)the Λp spectrum with stopped protons in the momentum range of 0.14< P_p <0.30 GeV/c from primary protons; e) The $\Lambda\gamma$ - spectrum for all combinations without total weight from Λ and γ; f)the $\Lambda\gamma$ spectrum with total weight. The dashed curve is the experimental background fitted by polynomial function.

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